

Z Rheumatol

<https://doi.org/10.1007/s00393-024-01543-6>

Accepted: 11 June 2024

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Redaktion

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Effects of video-based cervical stabilization home exercises in patients with rheumatoid arthritis: a randomized controlled pilot study

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Abstract

Objective: This study aimed to examine the effects of a remote video-based cervical stabilization exercise program on cervical proprioception, functional status, and disease-related quality of life in patients with rheumatoid arthritis (RA).

Design: Patients with RA were evaluated regarding cervical joint positioning error, cervical region functional status (Neck Disability Index), general functional status (Health Assessment Questionnaire), and disease-related quality of life (Rheumatoid Arthritis Quality of Life Scale). Patients were randomized to exercise ($n = 14$, 10 female) and control ($n = 12$, 9 female) groups. Patients in the exercise group performed a video-based home exercise program consisting of progressive cervical stabilization exercises three times a week for six weeks in addition to their routine medication. The patients in the control group continued their routine medication only. Evaluations were repeated in both groups in the seventh week following the baseline evaluation.

Results: Groups were similar at baseline ($p > 0.05$). Patients in both groups had low disease activity (DAS-28 CRP ≤ 3.2). The remote video-based exercise program led to significant improvements in cervical proprioception, functional status, and disease-related quality of life ($p < 0.05$). No significant changes were detected in any parameters in the control group ($p > 0.05$). Obtained changes were superior in the exercise group compared to the control group ($d > 1.00$, $p < 0.05$).

Conclusion: Cervical stabilization exercises may increase cervical proprioception, improve functional status, and enhance disease-related quality of life in patients with RA when administered as a remote program.

Trial number: <https://clinicaltrials.gov/study/NCT04948775>, NCT04948775.

Keywords

Spine · Sense · Functional status · Quality of life · Telerehabilitation



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Introduction

Rheumatoid arthritis (RA) is a chronic disease characterized primarily by symmetrical and multi-involvement of synovial joints [1]. The involvement of cervical

joints in patients with RA was initially described by Garrod in 1890, and RA is regarded as the type of inflammatory arthritis that affects the cervical spine most significantly [2]. Inflammation of atlantoaxial joint junction, facet joints, uncovertebral

joints, retro-dental bursa, interspinous ligaments, and ligaments around the cervical joints may result in pannus formation, odontoid erosion, and ligament laxity, which may eventually lead to joint damage and cervical instability in RA [3–5]. Cervical proprioceptive sense may be impaired in patients with RA due to these changes [6].

Proprioceptive sense is defined as a type of specialized sensory model that includes the sense of joint movement (kinesthesia), the sense of joint position, and the magnitude of the force of movement [7]. The proprioceptive system is controlled by connections between mechanoreceptors located in joints, ligaments, tendons and/or skin, muscle spindles localized in muscles, nerve fibers carrying proprioceptive sense, and cells in the dorsal horn of the spinal cord [7, 8]. Muscle spindles located in the cervical deep muscles contribute to cervical proprioception sense most significantly [9]. Accordingly, the beneficial effects of cervical stabilization exercises and cervical proprioceptive exercises on cervical proprioception, as well as of taping and spinal mobilization targeting the deep neck flexors, have been reported for various neck problems [10–13]. However, the effectiveness of therapeutic approaches for cervical proprioception in patients with RA remains unexplored.

Therefore, the present pilot study primarily aimed to determine the effects of cervical stabilization exercises on cervical proprioception in patients with RA. The secondary aim was to evaluate the effects of cervical stabilization exercises on functional status and disease-related quality of life in these patients.

Methods

This was a prospective randomized controlled pilot study. The data collection was carried out between November 2020 and April 2021 at Izmir Katip Celebi University Hospital. Ethical permission was obtained from the ethics committee of Izmir Katip Celebi University on 19.11.2020 with decision number 1078. The study was registered at ClinicalTrials.gov with ID number: NCT04948775.

Participants

Adult patients (> 18 years old) who were classified as RA according to ACR/EULAR 2010 classification criteria were invited to join the study [14]. Patients were included if they agreed to participate in the study and were literate in the Turkish language. Patients with (a) a history of trauma/surgery involving the neck area, (b) a vestibular system problem, (c) ongoing regular physiotherapy, and (d) discomfort during cervical stabilization exercises were excluded. Signed informed consent was obtained from all participants who agreed to participate in the study.

The sample size was calculated in an a priori sample size calculation in the G*Power 3.1.9.2 software (Heinrich Heine University Düsseldorf, Düsseldorf, Germany) by using the smallest effect size ($d=0.846$) from the study by Lee et al., 5% type I error, and 20% type II error [15]. The total sample size was calculated to be 46 patients with RA (exercise group = 23, control group = 23). However, due to the COVID-19 pandemic, recruitment did not reach to the calculated sample size and the study was completed as a pilot study. The flow diagram of the study is provided in **Fig. 1**.

Randomization

Patients were randomly divided into two groups (exercise and control) using sealed opaque envelopes.

Interventions

Patients were assessed at baseline and the seventh week. Patients who did not attend to the follow-up assessment within a week were excluded from the study. Both groups maintained their routine medication. The exercise group underwent a 6-week (3 times/week) remotely performed cervical stabilization exercise program. The control group did not receive additional interventions.

In the exercise group, progressive cervical stabilization exercises targeting the deep neck flexor muscles were delivered to the patients as video messages via their mobile phones via a free messaging service (WhatsApp Messenger; Meta, CA, USA) on

a weekly basis. The details of the exercise program, which was utilized in axial spondylarthritis (axSpA), have been published previously [16]. The exercise program lasted 15–20 mins in the first week and progressed to 40–45 min in the last week. Adherence to the exercise program was monitored weekly via the same messaging service.

Outcome measures

Physical (sex, age, body mass index), sociodemographic (marital status, educational status, employment status), and disease-related (disease duration, disease activity based on DAS-28 CRP, medications) characteristics of the patients were recorded by using a structured form. Cervical proprioception, functional status, and disease-related quality of life were evaluated using standardized methods and validated questionnaires.

Primary outcome measures

Cervical proprioception

The cervical joint positioning error method (flexion, extension, right rotation, left rotation, right lateral flexion, and left lateral flexion) was used to evaluate cervical proprioception. Details of the method have been described in a previous study [16]. Higher values indicate poorer cervical proprioception.

Secondary outcome measures

Cervical region functional status

The functional status of the cervical region was evaluated using the Turkish version of the Neck Disability Index (NDI) [17]. The NDI comprises 10 questions, each was scored between zero and five. Higher scores indicate greater functional impairment.

General functional status

Turkish version of the Health Assessment Questionnaire (HAQ) was used to determine general functional status [18]. The HAQ consists of 20 questions and has eight subheadings including dressing, sitting, eating, walking, hygiene, reaching, grasping, and daily living activities. Each question is graded between 0 and 3 points (0=

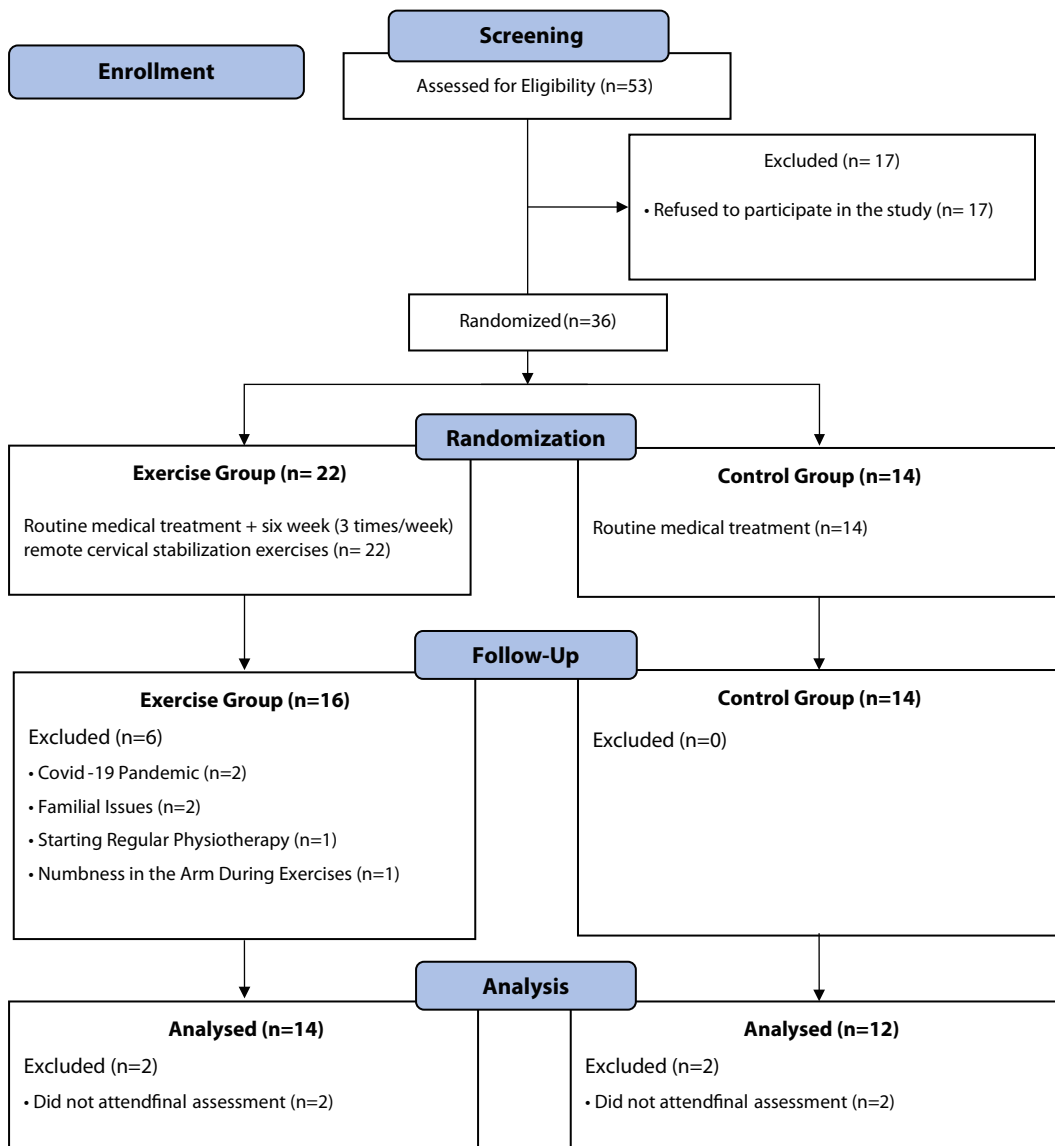


Fig. 1 ◀ Flow-diagram of the study

no difficulty, 1 = some difficulty, 2 = much difficulty, and 3 = unable to do). The total score is obtained by summing all individual subheading scores and dividing by 8. Higher scores reflect poorer functional status.

Disease-related quality of life

The Turkish version of the Rheumatoid Arthritis Quality of Life Scale (RAQoL) was used to evaluate disease-related quality of life [19]. RAQoL includes 30 items that evaluate disease-related symptoms, fatigue, mood, sleep quality, and functional limitations due to severe joint involvement, and the answer to each item is scored as 0 = no and 1 = yes. The total score ranges

from 0 to 30, with higher scores indicating lower quality of life.

Statistical analysis

The Statistical Package for Social Sciences for Windows (SPSS version 20.0; IBM Corp., Armonk, NY, USA) program was used for statistical analysis. Shapiro–Wilk test, histograms, detrended Q-Q graphs, and kurtosis and skewness values were examined to determine the distribution of continuous data. Data did not exhibit a normal distribution. Categorical variables were expressed as numbers (*n*) and percentages (%). Continuous data were expressed as median and 25th/75th interquartile range (IQR 25th/75th). Fisher’s

exact test or Pearson chi-square test was used to compare categorical variables between groups. Mann–Whitney U test was used to compare independent groups, and the Wilcoxon signed-rank test was used to compare dependent groups. The effect size was calculated by converting the Mann–Whitney U values into Cohen’s *d* values as suggested by Fritz et al. Effect sizes were interpreted as follows: small: $0.2 \leq d < 0.5$, medium: $0.5 \leq d < 0.8$, and large: $0.8 \leq d$ [20]. A *p*-value < 0.05 was considered statistically significant for all analyses.

| Table 1 Baseline assessment | | | | |
|---|-------------|---|---|---------------------|
| | | Exercise group (n = 14) | Control group (n = 12) | p-value |
| | | n (%) or median (IQR 25 th /75 th) | n (%) or median (IQR 25 th /75 th) | |
| <i>Physical characteristics</i> | | | | |
| Sex | Female | 10 (71) | 9 (75) | >0.999 ^a |
| | Male | 4 (29) | 3 (25) | |
| Age (years) | | 61.0 (60.0/63.8) | 55.5 (52.3/61.0) | 0.071 ^b |
| Body mass index (kg/m ²) | | 28.7 (25.3/30.0) | 28.1 (23.2/29.3) | 0.488 ^b |
| <i>Sociodemographic characteristics</i> | | | | |
| Marital status | Married | 13 (93) | 10 (83) | 0.580 ^a |
| | Single | 1 (7) | 2 (17) | |
| Educational status | Literate | 0 (0) | 1 (8) | 0.224 ^c |
| | Elementary | 10 (71) | 6 (50) | |
| | Secondary | 1 (7) | 4 (33) | |
| | High | 2 (14) | 0 (0) | |
| | University | 1 (7) | 1 (8) | |
| Employment status | Working | 2 (14) | 5 (42) | 0.190 ^a |
| | Not Working | 12 (86) | 7 (58) | |
| <i>Disease-related characteristics</i> | | | | |
| Disease duration (years) | | 9.5 (5.5/15.0) | 7.0 (5.0/14.3) | 0.699 ^b |
| DAS-28 CRP (score 0–10) | | 3.1 (2.1/4.0) | 3.2 (2.1/3.8) | 0.810 ^b |
| <i>Cervical proprioception error</i> | | | | |
| Flexion (°) | | 6.5 (4.5/10.6) | 9.1 (4.6/13.7) | 0.354 ^b |
| Extension (°) | | 9.1 (5.7/14.0) | 10.2 (5.5/17.3) | 0.777 ^b |
| Right lateral flexion (°) | | 8.4 (4.7/14.2) | 8.7 (5.7/12.0) | 0.918 ^b |
| Left lateral flexion (°) | | 8.9 (5.5/14.0) | 8.3 (5.4/12.8) | 0.817 ^b |
| Right rotation (°) | | 8.8 (6.0/11.6) | 8.4 (4.5/13.8) | 0.857 ^b |
| Left rotation (°) | | 7.8 (5.5/11.5) | 5.8 (4.7/11.5) | 0.554 ^b |
| <i>Functional status</i> | | | | |
| NDI (score 0–50) | | 10.0 (7.0/15.3) | 4.0 (2.0/17.8) | 0.141 ^b |
| HAQ (score 0–3) | | 0.5 (0.2/1.3) | 0.6 (0.1/1.1) | 0.680 ^b |
| <i>Disease-related quality of life</i> | | | | |
| RAQoL (score 0–30) | | 19.0 (12.3/22.3) | 15.5 (3.3/25.0) | 0.837 ^b |

DAS-28 CRP Disease Activity Score 28 C-reactive protein, *HAQ* Health Assessment Questionnaire, *IQR 25th/75th* interquartile range 25th/75th, *NDI* Neck Disability Index, *n* number, *RAQoL* Rheumatoid Arthritis Quality of Life Scale

^aFisher's exact test
^bMann–Whitney U test
^cPearson chi-square test

Results

The study was completed with 26 patients with RA (exercise group = 14, control group = 12). There were no differences between groups at baseline (Table 1, $p > 0.05$). Twelve patients (exercise 6, control 6) were using corticosteroids + conventional disease-modifying anti-inflammatory drugs (DMARDs), and 12 patients (exercise 6, control 6) were using conventional DMARDs only. In the exercise group, one patient was using biologic DMARDs (rituximab), and one patient was under

no medication. No statistical difference was found between the groups regarding medication ($p > 0.999$). All patients in the exercise group reported 100% adherence to their exercise program.

While statistically significant improvements were detected in all parameters in the exercise group ($p < 0.05$, Table 2), no significant changes were detected in any of the parameters in the control group ($p > 0.05$, Table 2).

Delta values (follow-up–baseline) compared between the groups revealed that the exercise group was superior to the

control group in all parameters, with high effect sizes (Table 3, $p < 0.05$ d > 1.00).

Discussion

This pilot study was conducted to investigate the effects of a video-based cervical stabilization home exercise program in patients with RA. Performing this program targeting the deep neck flexors three times a week for six weeks improved cervical proprioception, functional status, and disease-related quality of life. Furthermore, patients who underwent this pro-

| Table 2 Changes in the groups | | | | | | |
|--|--|---|----------------------|--|---|----------------------|
| | Exercise group (n = 14) | | | Control group (n = 12) | | |
| | Before: median (IQR 25 th /75 th) | After: median (IQR 25 th /75 th) | p-value ^a | Before: median (IQR 25 th /75 th) | After: median (IQR 25 th /75 th) | p-value ^a |
| <i>Cervical proprioception error</i> | | | | | | |
| Flexion (°) | 6.5 (4.5/10.6) | 2.6 (1.8/4.5) | 0.002* | 9.1 (4.6/13.7) | 13.4 (8.3/18.8) | 0.195 |
| Extension (°) | 9.1 (5.7/14.0) | 4.3 (2.7/6.2) | 0.001* | 10.2 (5.5/17.3) | 15.0 (6.7/21.6) | 0.158 |
| Right lateral flexion (°) | 8.4 (4.7/14.2) | 3.6 (2.4/5.5) | 0.001* | 8.7 (5.7/12.0) | 12.7 (5.8/15.4) | 0.158 |
| Left lateral flexion (°) | 8.9 (5.5/14.0) | 4.0 (3.2/5.8) | 0.004* | 8.3 (5.4/12.8) | 10.5 (5.7/15.2) | 0.289 |
| Right rotation (°) | 8.8 (6.0/11.6) | 4.7 (3.5/6.1) | 0.002* | 8.4 (4.5/13.8) | 11.9 (7.2/21.7) | 0.084 |
| Left rotation (°) | 7.8 (5.5/11.5) | 4.9 (2.7/6.1) | 0.012* | 5.8 (4.7/11.5) | 10.0 (5.5/21.7) | 0.158 |
| <i>Functional status</i> | | | | | | |
| NDI (score 0–50) | 10.0 (7.0/15.3) | 2.5 (1.8/5.8) | 0.001* | 4.0 (2.0/17.8) | 8.0 (4.2/21.8) | 0.112 |
| HAQ (score 0–3) | 0.5 (0.2/1.3) | 0.1 (0.1/0.4) | 0.001* | 0.6 (0.1/1.1) | 0.6 (0.2/1.4) | 0.235 |
| <i>Disease-related quality of life</i> | | | | | | |
| RAQoL (score 0–30) | 19.0 (12.3/22.3) | 7.5 (3.0/12.0) | 0.001* | 15.5 (3.3/25.0) | 15.5 (6.3/26.5) | 0.170 |
| HAQ Health Assessment Questionnaire, IQR 25 th /75 th interquartile range 25 th /75 th , NDI Neck Disability Index, RAQoL Rheumatoid Arthritis Quality of Life Scale | | | | | | |
| *statistically significant; p < 0.05 | | | | | | |
| ^a Wilcoxon signed-rank test | | | | | | |

| Table 3 Comparison of delta values between groups | | | | |
|---|--|--|----------------------|------|
| | Exercise group (n = 14) | Control group (n = 12) | p-value ^a | d |
| | Median (IQR 25 th /75 th) | Median (IQR 25 th /75 th) | | |
| <i>Cervical proprioception error</i> | | | | |
| Δ Flexion (°) | –3.4 (–8.2/–1.1) | 3.6 (–2.0/7.6) | 0.005* | 1.30 |
| Δ Extension (°) | –4.3 (–8.9/–2.8) | 4.4 (–0.8/8.1) | 0.001* | 1.67 |
| Δ Right lateral flexion (°) | –3.2 (–10.9/–1.6) | 3.7 (–1.3/6.6) | 0.002* | 1.48 |
| Δ Left lateral flexion (°) | –3.5 (–11.4/–0.7) | 1.2 (–1.3/5.0) | 0.002* | 1.48 |
| Δ Right rotation (°) | –3.5 (–7.8/–1.5) | 4.1 (–3.5/13.2) | 0.009* | 1.20 |
| Δ Left rotation (°) | –4.1 (–5.6/0) | 0.8 (–2.1/14.0) | 0.007* | 1.25 |
| <i>Functional status</i> | | | | |
| Δ NDI (score 0–50) | –5.0 (–10.5/–4.0) | 2.5 (–1.5/6.3) | <0.001* | 2.64 |
| Δ HAQ (score 0–3) | –0.3 (–0.6/–0.1) | 0 (–0.2/0.4) | 0.001* | 1.60 |
| <i>Disease-related quality of life</i> | | | | |
| Δ RAQoL (score 0–30) | –6.5 (–12.5/–4.0) | 1.0 (0.0/2.0) | <0.001* | 2.22 |
| HAQ Health Assessment Questionnaire, IQR 25 th /75 th interquartile range 25 th /75 th , NDI Neck Disability Index, n number, RAQoL Rheumatoid Arthritis Quality of Life Scale, Δ delta (follow-up—baseline), d effect size, ° degree | | | | |
| *statistically significant p < 0.05 | | | | |
| ^a Mann–Whitney U test | | | | |

gram in addition to their routine medication experienced significantly greater improvements in all evaluated variables compared to patients who followed their routine medication alone. To the best of our knowledge, this study is the first to investigate the effects of cervical stabilization exercises in patients with RA.

Positive effects of this exercise program on cervical proprioception have been shown previously in patients with axSpA [16]. Other authors employed similar cervical stabilization exercise programs (in form

of flattening cervical lordosis) focusing on deep neck flexors to the present study and reported improved cervical proprioception error [12, 15]. Muscle spindles are primarily responsible for joint position sense, and both previous studies and results from the present study suggest a positive effect of cervical stabilization exercises targeting deep neck flexors (which are rich with muscle spindles) on cervical proprioception error [8, 12, 15, 21]. Although Ulutatar et al. could not detect a relationship between cervical positioning error and pain,

functional status, and disease-related quality of life in patients with RA, the results of the present study suggest that cervical stabilization exercises may also be used to improve these parameters [6].

The exercise program + routine medication used in the present study led to superior results compared to routine medication alone in patients with RA, which was not observed in patients with axSpA [16]. The difference between the two conditions may be related to the pathophysiology of the cervical involvement. Cer-

vical proprioceptive impairment in RA is likely secondary to destruction of the inner joint surfaces due to the pannus tissue and cervical ligament laxity; on the other hand, this deterioration occurs due to osteophyte formation and ankylosis of the cervical vertebrae in axSpA.

The present study was conducted during the COVID-19 pandemic. Thus, the exercise program was delivered to patients weekly via video messages using a free application (WhatsApp Messenger; Meta, CA, USA) to reduce the risk of contact and ensure continuity of the exercise program, which could have been adversely affected by curfews. Exercise adherence and adverse effects were followed up weekly using the same messaging service. For the participants who completed the study, the adherence rate was determined at 100%. However, these reported rates may not reflect the reality, as they were based on patient reports. Five patients (23%) who did not perform their exercises regularly due to varying reasons were excluded from the study. Despite reporting various reasons such as family issues ($n=2$) and the COVID-19 pandemic ($n=2$), a lack of familiarity with the exercises and the absence of face-to-face supervision likely contributed to these patients' non-compliance with the program. Indeed, one of the excluded patients decided to undergo a supervised physiotherapy program. Exercise compliance may be improved by performing this exercise program under supervision in future studies. Another participant in the exercise group was unable to continue the exercise program due to experiencing numbness in the arm during the exercises. Subsequent examination revealed cervical disc herniation in this patient, who was then referred to neurosurgery. In this context, it may be important to screen patients for myelopathy before initiating a similar exercise program.

The median age of patients in the exercise group was higher than that of patients in the control group. Although this difference was not statistically significant, one may suggest that joint position sense could potentially decrease with age. However, previous studies reported that age has no effect on joint position error [6, 22].

This study has several limitations. First, the targeted sample size could not be

reached, and the drop-out rate was relatively high. Cervical proprioception was examined only in terms of position sense. Other components of proprioception, such as kinesthesia or the sense of movement, could not be evaluated. Moreover, the effect of cervical stabilization exercises on balance, which is closely related to proprioception, could not be determined. Another limitation is the lack of follow-up periods that would allow us to determine how long the achieved improvements might be maintained.

Conclusion

In conclusion, positive effects of a 6-week video-based home exercise program performed three times a week were determined on cervical proprioception evaluated by cervical joint positioning error along with improvements in functional status and disease-related quality of life in patients with RA. While routine medication alone did not have a significant effect on cervical joint positioning error, functional status, and disease-related quality of life during the investigated period, the exercise program added to routine medication resulted in significant changes in all evaluated parameters. Optimization of this exercise program in terms of exercise characteristics (such as duration, weekly frequency, repetition, etc.) should be investigated in future studies.

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Author Contribution. Deniz Bayraktar, Mustafa Oguz Gulcema, Devrim Can Sarac, Dilek Solmaz, and Servet Akar contributed to study conception and design. Data collection was performed by Gozde Duran, Gulay Alp, and Sercan Guccenmez. Statistical analysis was performed by Devrim Can Sarac. The first draft of the manuscript was written by Mustafa Oguz Gulcema. Critical review of the manuscript was performed by Deniz Bayraktar. All authors read and approved the final version of the manuscript.

Data availability. The study data are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest. M.O. Gulcema, D.C. Sarac, G. Alp, G. Duran, S. Guccenmez, D. Solmaz, S. Akar, and D. Bayraktar declare that they have no competing interests.

All procedures performed in studies involving human participants or on human tissue were in accordance with the ethical standards of the institutional and/or national research committee of Izmir Katip Celebi University on 19.11.2020 (decision number 1078) and with the 1975 Helsinki declaration and its later amendments or comparable ethical standards. Trial number: clinicaltrials.gov, NCT04948775. Informed consent was obtained from all individual participants included in the study.

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Auswirkungen eines häuslichen, videobasierten Trainings zur Stabilisierung der Halswirbelsäule bei Patienten mit rheumatoider Arthritis: eine randomisierte, kontrollierte Pilotstudie

Ziel: Ziel dieser Studie war es, die Auswirkungen eines ferngesteuerten videobasierten Übungsprogramms zur Stabilisierung der Halswirbelsäule auf die zervikale Propriozeption, den Funktionsstatus und die krankheitsbezogene Lebensqualität von Patienten mit rheumatoider Arthritis (RA) zu untersuchen.

Studiendesign: Patienten mit RA wurden hinsichtlich der Fehlstellung des Halsgelenks, des Funktionsstatus der Halswirbelsäule (Neck Disability Index), des allgemeinen Funktionsstatus (Health Assessment Questionnaire) und der krankheitsbezogenen Lebensqualität (Rheumatoid Arthritis Quality of Life Scale) zu Baseline untersucht. Anschließend wurden sie randomisiert einer Interventions- ($n = 14$, 10 Frauen) und einer Kontrollgruppe ($n = 12$, 9 Frauen) zugeteilt. Patienten der Interventionsgruppe führten ein häusliches, videobasiertes Trainingsprogramm durch, das aus progressiven Übungen zur Stabilisierung der Halswirbelsäule bestand. Dies erfolgte dreimal wöchentlich über einen Zeitraum von sechs Wochen. Patienten beider Gruppen erhielten in diesem Zeitraum ihre medikamentöse Routineversorgung. Die Messungen zum Interventionsende erfolgten analog zur Eingangsuntersuchung vor Interventionsbeginn.

Ergebnisse: Die Gruppen waren zu Studienbeginn vergleichbar ($p > 0,05$). Patienten beider Gruppen hatten eine geringe Krankheitsaktivität (DAS-28 CRP $\leq 3,2$). Das videobasierte Übungsprogramm führte zu signifikanten Verbesserungen der zervikalen Propriozeption, des funktionellen Status und der krankheitsbezogenen Lebensqualität ($p < 0,05$). In der Kontrollgruppe wurden hingegen keine signifikanten Veränderungen hinsichtlich der untersuchten Parameter festgestellt ($p > 0,05$). Die erzielten Veränderungen waren in der Interventionsgruppe besser als in der Kontrollgruppe ($d > 1,00$, $p < 0,05$).

Schlussfolgerung: Ein videogestütztes Heimtrainingsprogramm zur Stabilisierung der Halswirbelsäule kann bei Patienten mit RA die zervikale Propriozeption, den Funktionsstatus sowie die krankheitsbezogene Lebensqualität verbessern.

Schlüsselwörter

Wirbelsäule · Sinn · Funktionaler Status · Lebensqualität · Telerehabilitation